

I. Please amend Paragraphs [0001], [0003], [0019], [0021], [0032], [0034], [0035], [0036], and [0038] of the specification as follows:

[0001] This application is a continuation of our co-pending application Serial Number 09/803,592 filed on March 9, 2001, MICRO COMPONENT LIQUID HYDROCARBON REFORMER SYSTEM AND CYCLE FOR PRODUCING HYDROGEN GAS, now abandoned, and our co-pending application Serial Number 09/847,727 filed on May 2, 2001 which issued as United States Letters Patent Number 6,716,400 on April 6, 2004, "Ignition System For a Fuel Cell Hydrogen Generator."

[0003] Hydrogen fuel cells are non-polluting, highly efficient power sources. See, for example, various publications at the web site of the United States Department of Energy [at the URL: [www.eren.doe.gov/RE/hydrogen\\_fuel\\_cells.html](http://www.eren.doe.gov/RE/hydrogen_fuel_cells.html). See, for example, and Fuel Cells Green Power, Los Alamos National Laboratory, U.S. Department of Energy, 1999.

[0019] Water and gasoline are vaporized then mixed; the mixture is processed and ultimately directed to a high temperature steam reformer and then to a water gas shift reactor where hydrogen gas is produced in known reactions approximated by the equations:  $C_8H_{18} + 12H_2O \rightleftharpoons 4CO + 4CO_2 + 21H_2$  and  $CO + H_2O \rightarrow CO_2 + H_2$ .

[0021] The cycle is started using hydrogen from the fuel cell off gas that is stored in a suitable vessel interconnected with the system. The cycle operates independently after start-up. A suitable starting device is described in our United States Patent 6,716,400 "Ignition System For a Fuel Cell Hydrogen Generator" issued on April 6, 2004 from application serial number

09/847,727, filed on May 2, 2001 [application "Micro Component Start Module for a Hydrogen Generation System" ~~[(to be filed)]~~]. The starting device is a module that includes a vaporizer and a combustor initiated by the stored fuel cell off gas hydrogen. Once initiated and operating, the heat energy source for the system comprises vaporized hydrocarbons and fuel cell off gas that provide the energy to drive the system. The off gas/hydrocarbon mixture is catalytically combusted in the system in micro component vaporizer and steam reformer devices that are serially interconnected in conformance with the processing sequences described herein. After the steam reformer processing, H<sub>2</sub> is produced in a gas mixture which is then treated in a water gas shift reactor and preferentially oxidized before the gas is introduced into the fuel cell to remove CO that may otherwise poison the fuel cell.

[0032] Figure 3A illustrates in enlarged detail a section of a wavyplate separator in a micro component assembly used in the system, and the relationship of the separator to fluid flows on its opposite sides. The separate fluid flows on the opposite sides of the wavyplate may be in the same or in opposite directions. In Figure 3A, a shaped or folded wavyplate 320 has two opposite sides 321 and 322 (322 is shown coated with a catalyst material 324), respectively exposed to laminar fluid flows 331 and 332 in a heat exchanger assembly. Such types of devices used in the system are described in United States application for patent Serial Number 09/627,267, filed July 28, 2000 for "Multi-purpose Micro Channel Micro Component" owned by the assignee[s] of the present application, a division of which issued as United States Patent 6,946,113 on September 20, 2005, "Method for Processing Fluid Flows in a Micro Component Reformer System".

[0034] In the various modules used in the system, the separator should be as thin and rigid as possible, in the order of magnitude of approximately 100 microns to approximately 1000 microns as a maximum. Inconel<sup>®</sup>, a family of trademarked nickel-chromium-iron alloys, is a useful material. Design parameters depend on accommodating thinness with separator rigidity and heat transfer characteristics, *i.e.*,  $\Delta T^\circ/\text{Thickness}$ . In the operation of the cycle, heat transfer between fluids is optimally balanced depending on the flow rate of the fluid passing in the steam reformer, the rate of steam reforming, the catalysts on both sides, the capability of the oxidation catalyst and the flow rate on the oxidation side. Heat utilization an/or catalyst characteristics on the steam reforming side are design factors.

[0035] Figure 3C shows a section of a micro component module 320 with a wavyplate separator 321 forming [~~laminar flow~~] channels for laminar flow, 331 and 332, on both sides of a separator in an enclosure having lower and upper sides 335A and 335B. For clarity, the right and left sides and inlet and outlet orifices for flow in the channels of the module are not shown. As noted above, micro component assemblies useful to be adapted to vaporizer, heat exchanger, steam reformer and water/gas shift devices for the system are described in [co-pending application Serial No. 09/627,267 owned by the assignee of the present application] United States Patent 6,946,113 .

[0036] With reference to the various system modules shown in Figure 1, the following Table I relates the modules to reference numerals in the drawings, functions and reactions accomplished, and the approximate preferred (design optimum) temperatures related to the fluid processing accomplished therein:

TABLE I

<u>Module Reference No.</u>	<u>Function</u>	<u>Reaction</u>	<u>Temperature °C</u>
14	Vaporizer	Hydrocarbon (gasoline) fuel is vaporized.	25° in / 350° out
18	Vaporizer	Liquid water is vaporized.	In: 25° Out: 500° +/- 200°
22	Vaporizer	Hydrocarbon (gasoline) fuel is vaporized.	In: 25° Out: 500° +/- 200°
30	Heat Exchanger	The temperature of the ydrocarbon/water vapor mixture is increased.	In: 500° +/- 200° Out: 800° +/- 200°
34	Steam Reformer	Catalyst induced reaction to produce syn-gas: H <sub>2</sub> , CO <sub>2</sub> , CO, H <sub>2</sub> O, and CH <sub>4</sub> .	800° +/- 200°
38	Heat Exchanger		In: 800° +/- 200° Out: 350°

42	Water/Gas Shift Reactor	CO is removed from the syn-gas. $\text{CO} + \text{H}_2\text{O} \longleftrightarrow \text{H}_2 + \text{CO}_2$	350°
46	Heat Exchanger		In: 350° [±/] (approximate) Out: 200° [±/] (approximate)
50	Water/Gas Shift Reactor	CO in syn-gas is optimally reduced to 10ppm. $\text{CO} + \text{H}_2\text{O} \longleftrightarrow \text{H}_2 + \text{CO}_2$	200°
54	Heat Exchanger		100° [±/] (approximate)
60	Preferential Oxidizer		100° [±/] (approximate) )

**[0038]** In a similar manner, Table II [{} considered in conjunction with Figure 1 [and Figure 2]] relates the micro component modules to the properties of the opposite sides of the separators in the devices with regard to the functions and/or reactions in the fluid flow passing on opposite sides and the catalyst properties of the respective separator sides. Useful catalysts identified with respect to the example include platinum, palladium, cerium oxide, aluminum hydroxide and cuprous oxide; other suitable catalysts may be substituted for

the functions specified. In steady state simulations, catalyst composition for the steam reformer and water gas shift reactors are not factors.

TABLE II

<u>Module</u> <u>Reference</u> <u>No.</u> <u>and</u> <u>Function</u>	<u>Separator Properties</u>	
	<u>Flow Side One</u>	<u>Flow Side Two</u>
14 [(Figure 4)] Vaporizer	Hydrocarbon (gasoline) fuel is vaporized. Catalyst: None Reference No. 14[a] ( <u>in</u> )	25° in / 350° out  Catalyst: : Pd, Pt Reference No. 14[b] ( <u>out</u> )
18 [(Figure 4)] 18a (Figure 4)] Vaporizer	Liquid water is vaporized. Catalyst: None Reference No. 18[a] ( <u>in</u> )	25° in / 350° out Combustor for HC and H <sub>2</sub> Catalyst: : Pd, Pt Reference No. 18[a] ( <u>out</u> )
22 Vaporizer	Hydrocarbon (gasoline) fuel is vaporized. Catalyst: None Reference No. 22[b] ( <u>in</u> )	25° in / 350° out Combustor for HC and H <sub>2</sub> Catalyst: : Pd, Pt Reference No. 22[a] ( <u>out</u> )

30 Heat Exchanger	The temperature of the hydrocarbon/water vapor mixture is increased. Catalyst: None Reference No. 30[a] ( <u>in</u> )	350° in / 700° out  Catalyst: : Pd, Pt Reference No. 30[b] ( <u>out</u> )
34 Steam Reformer	Oxidation side: Catalyst induced reaction To produce syn-gas: H <sub>2</sub> , CO <sub>2</sub> , CO, H <sub>2</sub> O, and CH <sub>4</sub> . Catalyst: Pd, Pt Reference No. 34[a] ( <u>in</u> )	Steam Reformer side: 700° Combustor for HC and H <sub>2</sub>  Catalyst: Pd, Pt/CeO/Al <sub>2</sub> O <sub>3</sub> Reference No. 34[b] ( <u>out</u> )
38 Heat Exchanger [(Figure 1)  Evaporator - Cooler (Figure 4)]	Catalyst: Pt/Pd  Reference No. 38[a] ( <u>in</u> )	700° in / 450° out  Catalyst: None  Reference No. 38[b] ( <u>out</u> )
42 Water/Gas Shift Reactor	CO is removed from the syn-gas. $\text{CO} + \text{H}_2\text{O} \longleftrightarrow \text{H}_2 + \text{CO}_2$ Catalyst: Pt, CeO Reference No. 42[b] ( <u>in</u> )	450° Heat exchange.  Catalyst: None Reference No. 42[a] ( <u>out</u> )

46 Heat Exchanger [(Figure 4)] Evaporator - Cooler (Figure 4)]	Catalyst: Pt, Pd  Reference No. 46[a] (in)	350° in / 250° out  Catalyst: None  Reference No. 46[b] (out)
50 Water/Gas Shift Reactor	CO in syn-gas is optimally reduced to 10ppm. $\text{CO} + \text{H}_2\text{O} \longleftrightarrow \text{H}_2 + \text{CO}_2$ Catalyst: CuO Reference No. 50[b] (in)	250° Heat Exchange.  Catalyst: None Reference No. 50[a] (out)
54 Heat Exchanger [(Figure 4)]	Catalyst: None Reference No. 54[a] (in)	100° Catalyst: None Reference No. 54[b] (out)
60 Preferential Oxidizer	Catalyst: Pt, Pd Reference No. 60 (in)	100° Catalyst: None Reference No. 60 (out)



**II. Please amend Figure 1 as indicated in the annexed drawing sheet which is indicated as a "Replacement Sheet."**

Corrections made are shown in red the copy of the original Figure 1 included in the annex.